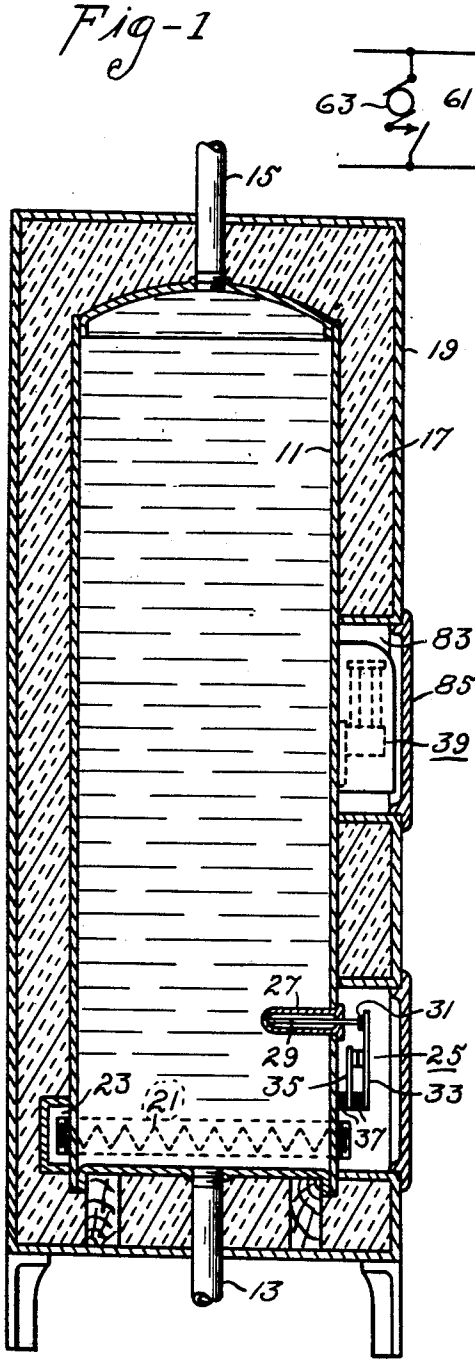
Jan. 16, 1945. C. M. OSTERHELD 2,367,370

WATER HEATER CONTROL SYSTEM

Filed Jan. 1, 1944 2 Sheets-Sheet 1

Fig-1



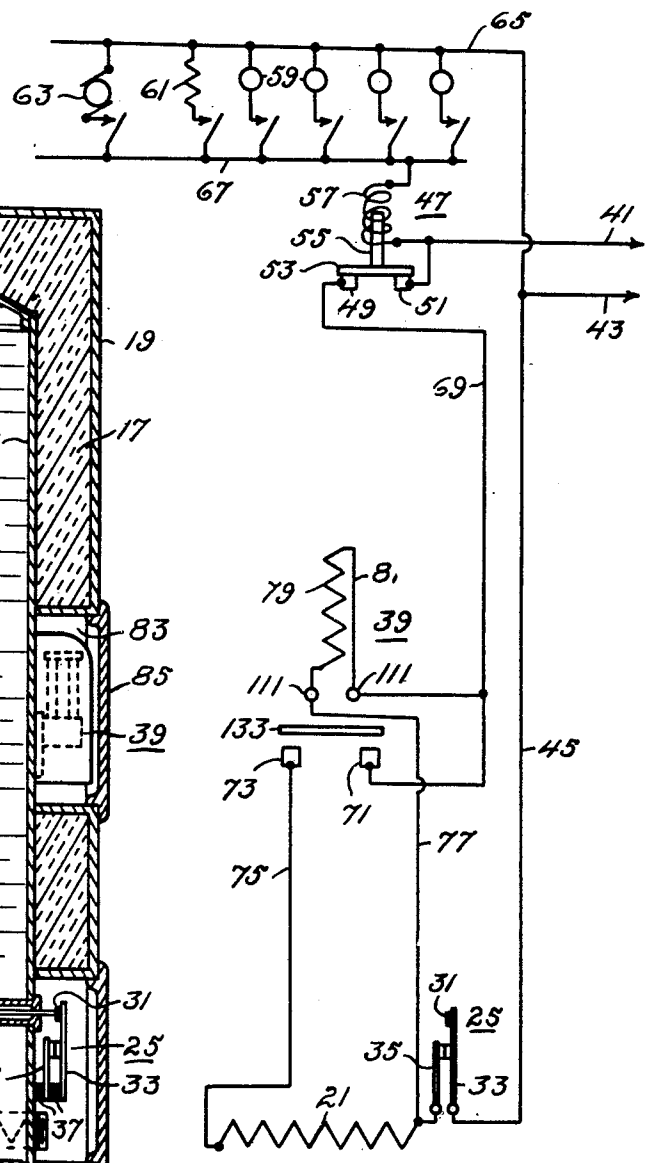


Fig-2

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WATER HEATER CONTROL SYSTEM

Filed Jan. 1, 1944 2 Sheets-Sheet 2

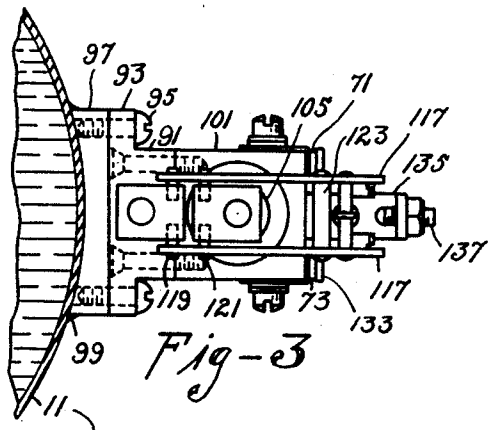


Fig-3

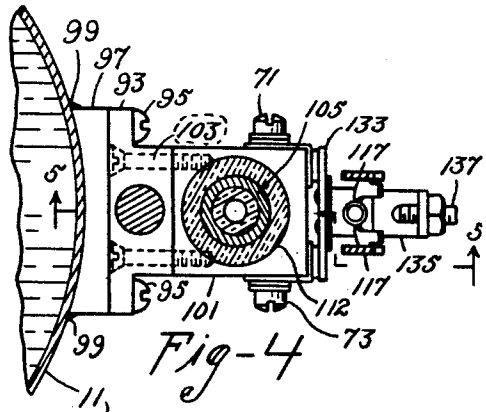


Fig-4

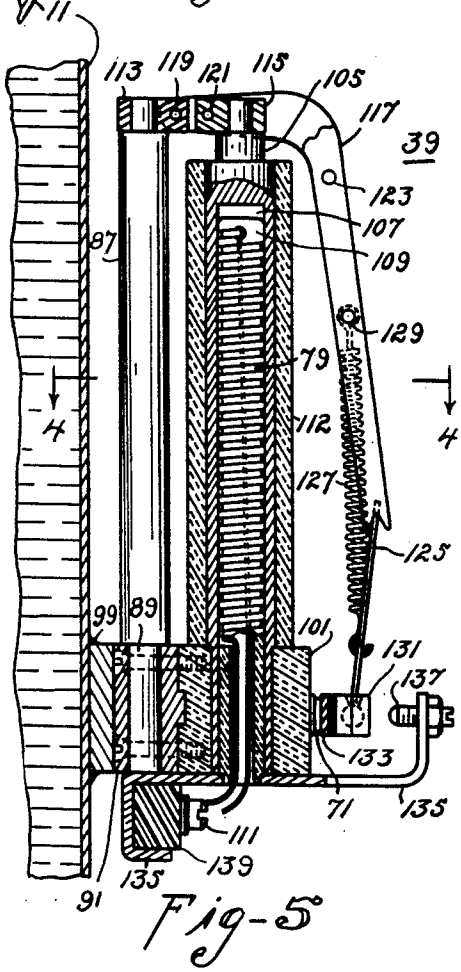


Fig-5

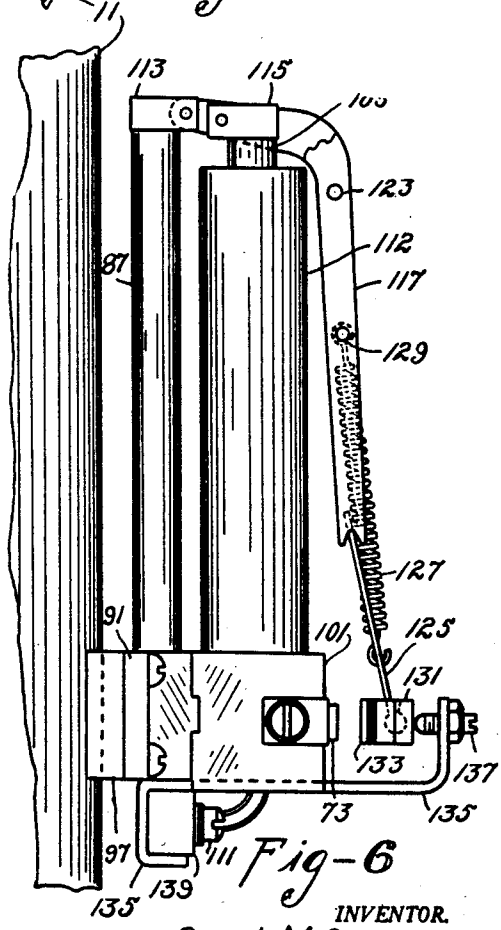


Fig-6

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Patented Jan. 16, 1945

2,367,370

UNITED STATES PATENT OFFICE

2,367,370

WATER HEATER CONTROL SYSTEM

Clark M. Osterheld, Stoughton, Wis., assignor to McGraw Electric Company, Elgin, Ill., a corporation of Delaware

Application January 1, 1944, Serial No. 516,692

11 Claims. (Cl. 219—39)

My invention relates to electric heating and particularly to tank water heater control systems.

An object of my invention is to provide a control system for a domestic tank water heater that shall be effective to prevent energization of the water heater when another circuit in the same house or home is carrying a heavy load.

Another object of my invention is to provide a control system for a domestic tank water heater that shall be effective to cause energization of a water heater with a preset time period of delay after a second circuit has had its load current reduced below a predetermined value in case only a relatively small amount of hot water has been withdrawn from the tank and that shall cause immediate energization of the water heater after said second circuit has had its load current reduced below a predetermined value in case a relatively large amount of hot water has been withdrawn from the tank.

Other objects of my invention will either be apparent from a description thereof or will be set forth during the course of such description and pointed out particularly in the appended claims.

In the drawings,

Figure 1 is a vertical sectional view of a domestic hot water tank with a thermal retarder unit at the center and a heating element at the lower portion of the tank,

Fig. 2 is a diagram of the electric circuits for the heating element retarder contacts and peak load limiter in connection with the house lighting, range and washing machine load,

Fig. 3 is a top plan view of the thermal retarder shown in Fig. 5,

Fig. 4 is a horizontal sectional view therethrough taken on the line 4—4 of Fig. 5,

Fig. 5 is a vertical sectional view on the line 5—5 of Fig. 4 showing the positions of the elements of the thermal retarder when there is cold water in the center of the tank, and,

Fig. 6 is a vertical plan view of the retarder showing its elements in their positions when the water in the center of the tank is hot.

Referring first of all to Fig. 1 of the drawings, I have there shown a hot water tank 11 having a lower cold water inlet pipe 13 and an upper hot water outlet pipe 15 mounted thereon. I provide also a covering 17 of suitable heat-insulating material, such as rock wool, and an outer casing 19 all as now well known in the art.

While I have shown a single electric heater 21 mounted thereon and located in a tunnel 23, I do not desire to be limited thereto. If only a single heater is used, I locate it adjacent the lower end of the tank.

I have shown a first thermal heater control switch designated generally by the numeral 25 and have illustrated this schematically as comprising a tube 27 having a closed inner end and having its outer end secured in a fluid-tight manner in an opening in the wall of the tank 11 near the lower end thereof. I provide an expansion rod 29 in the tube 27 adapted to engage a lug 31 of electric-insulating material which lug is secured to the outer end of a resilient contact arm 33 having a contact member thereon adapted to engage with and be disengaged from an inner substantially rigid contact arm 35. I have shown supporting and mounting means for the two contact arms 33 and 35 as comprising blocks 37 of suitable electric-insulating material.

Referring now to Fig. 2 of the drawings I have there shown a diagram of connections of the control system embodying my invention which includes in addition to the main or lower thermally-actuable heater control switch 25 a thermal retarder heater control switch unit 39 to be hereinafter described in detail.

I have shown a pair of supply circuit conductors 41 and 43, supply circuit conductor 43 being connected by a conductor 45 with resilient contact arm 33.

I have shown an electromagnetic heater control switch designated in its entirety by numeral 47, this switch including a pair of substantially fixed contact members 49 and 51, a contact bridging member 53 secured to a magnetic core 55 adapted to be energized by current flowing through a coil 57.

The electromagnetic switch 47 may be of the usual contactor type and so designed that upon the coil 57 being traversed by a current greater than a predetermined value, contact bridging member 53 will be moved upwardly out of engagement with contact members 49 and 51.

The heater circuit including the heater 21 is the first house load circuit and I have shown a second house load circuit adapted to have connected thereto and therewith the lights 59 in an ordinary home, an electric range 61 as well as the motor of a washing machine 63. Members 59, 61 and 63 are shown schematically only, each of these being controlled by the usual or suitable switches. One terminal of the members 59, 61 and 63 may be connected to a conductor 65 which is connected to supply circuit conductor

43. The other terminal of the elements 59, 61 and 63 may be connected to a second conductor 67 which is connected to one terminal of coil 57, the other terminal of coil 57 being connected to supply circuit conductor 41. Contact member 49 is connected by a conductor 69 to one terminal 71 of the thermal retarder switch unit while the other terminal 73 thereof is connected by a conductor 75 to one terminal of heater 21. The other terminal of heater 21 is connected first to rigid contact arm 35 while it is also connected by a conductor 77 to one terminal of a small heating coil 79 constituting a part of the thermal retarder switch unit to be hereinafter described in detail. The other terminal of heating coil 79 is connected by a conductor 81 with conductor 69 hereinbefore described.

Referring now to Figs. 3 to 6 inclusive, I have there illustrated one form of thermal retarder switch unit 39 which as shown in Fig. 1 of the drawings may be mounted in heat-conducting relation on the outside surface of the tank 11 at substantially the mid-portion thereof. I provide an opening 83 in the mass 17 of heat insulation to receive the thermal retarder unit, and I may provide also a cover 85 for said opening.

The thermal retarder heater control switch unit includes a first thermally-expansible rod 87 which has a lower end portion 89 of reduced diameter adapted to fit into an opening in a block 91 of heat-conducting material. The block 91 is provided with a pair of laterally-extending ears or lugs 93, through which extend a pair of machine screws 95 securing block 91 against a block 97 which has an arcuate inner surface and which may be held in proper operative position against the outer surface of tank 11 as by welding seams 99. Block 97 is also made of heat-conducting material such as a suitable metal or alloy.

I provide a block 101 of heat-insulating material which may be held against the front surface of block 91 as by a pair of machine screws 103. Block 101 is provided with an aperture therethrough into which fits the lower reduced end portion of a second expansion rod 105 having a central bore 107 extending therein from one end thereof. I provide a support 109 for the small heating coil 79, the terminals of heating coil 79 being connected to terminal members 111. An outer casing 112 surrounds the second expansion rod 105 and is of heat-insulating material.

The upper reduced end portion of the first high expansion rod 87 has a short lug 113 secured thereto while the upper reduced end portion of the second expansion rod 105 has secured thereto a short lug 115. The two arms extend toward each other. It may be here pointed out that while the first expansion rod 87 is of a relatively highly expansive material such as aluminum, the second expansion rod 105 is of a material such as metal or alloy having a lesser thermal expansivity than rod 87. I may use Invar for the second rod 105 or some other nickel steel or a chrome steel. The thermal expansivity of the second rod 105 may be on the order of one-half that of the first expansion rod 87.

It is to be noted that the ordinary temperature of cold water is 65° or 70° F. and that "hot" water has a temperature of 150° F. or slightly higher. Thus the first high expansion rod 87 will have its maximum length when subject to a temperature of 150° F. while the second low expansion rod 105 will have its maximum length when its temperature is on the order of 300° F. or higher. At these respective high temperatures the expansion characteristic of the two rods will be substantially the same, that is the lengths of the two rods will be substantially equal, and the switch controlled thereby will be closed.

A heater control switch actuable by the relative expansion of the two rods 87 and 105 may include an upper double bar toggle arm 117 which is of substantially L-shape, the horizontally extending portion thereof being pivotally supported on pivot pins 119 and 121 extending through the two arms and into the end portions of lugs 113 and 115. A cross bar 123 may be provided to hold the two bars of toggle arm 117 in proper operative position relatively to each other. I provide a lower or second toggle arm 125, the upper end of which has pivotal engagement with the lower end portion of the bars of toggle arm 117, and an over center spring 127 has its upper end connected to a cross bar 129 extending through the bars of toggle arm 117 while the lower end of spring 127 is connected with an intermediate portion of arm 125.

I provide a block 131 mounted on the lower end of toggle arm 125, this block supporting a contact bridging member 133 which is insulatedly mounted on block 131. Bridging member 133 is adapted to engage with and be disengaged from the fixed contact members 71 and 73 hereinbefore described.

I provide further a bracket 135 which may be suitably secured against the lower surface of block 101 and which has an adjustable stop screw 137 thereon. The bracket 135 may also be utilized to support terminals 111 which may be mounted on a block 139 of electric-insulating material supported by bracket 135.

The thermal retarder heater control switch unit is disclosed and claimed in my co-pending application of United States Letters Patent S. N. 511,387, filed November 22, 1943, and assigned to the same assignee as is the present application.

As has been hereinbefore stated one of the main objects of my invention is to ensure that the heater of the hot water tank shall not be energized during those times of the day or night when the second circuit energizing electric motors, the range, or the lights of the usual home is traversed by a relatively heavy current. In other words one of the objects of my invention is to prevent the occurrence of relatively heavy overloads or even relatively heavy loads on the supply circuit connected with the ordinary home. This is effected by the operation of the electromagnetic switch 47 which, when its coil is traversed by more than a predetermined amount of current, will interrupt the circuit to the heater 21 for the tank.

Another object of my invention is to provide a control system that shall be operative to cause immediate energization of the heater for a hot water tank after decrease of current in the second house-load circuit below a predetermined amount and that shall cause energization of the heater of the tank with a predetermined time delay in case only a relatively small amount of hot water has been withdrawn from the tank. It is to be understood that the heater 21 is to be energized immediately upon reclosure of the switch 47 controlled by the current in the second load circuit if the thermal retarder is subject to cold water in the tank, that is so much hot water has been withdrawn that substantially less than one-half of the water in the tank is hot, this hot water being located in the upper portion of the tank. Delayed energization of the heater 21 is to be ef-

fected in case the lower thermal heater control switch 25 only is subject to cold water.

The thermal retarder switch unit is shown in Fig. 5 of the drawings in its closed circuit position which will occur if the temperature of the two expansion rods 87 and 105 are at substantially the same value. This will be the case when the tank 11 is first filled with cold water, under which conditions the lower thermal heater control switch 25 will be closed and the two expansion rods 87 and 105 will be at substantially ordinary room temperature. If it be assumed that the load connected with the second circuit is small enough so that switch 47 is closed, the auxiliary heater coil 79 will be energized, but the design, construction and adjustment of the thermal retarder is such, preferably, that it will require from three to five hours before the second expansion rod 105 will have been heated sufficiently to cause expansion thereof to an amount to cause operation of the switch to its closed circuit position. If the lengths of rods 87 and 105 are short, the switch will be in closed circuit position but if the first and high expansion rod 87 is subject to the temperature of hot water in the tank, while the heating coil 79 has been energized less than a predetermined length of time, the switch will be in the open circuit position substantially as shown in Fig. 6 of the drawings.

The thermal retarder switch will be in the open circuit position when sufficient water in the upper portion of the tank has been heated so that the bottom dividing line thereof is below the thermal retarder switch 39. If this amount of water was heated in less time than required for the second expansion rod 105 to be heated to its maximum operating temperature, on the order of 300° F. or over, the switch will be moved to open position, but will again be moved to closed position when the second rod 105 has been heated sufficiently by reason of the continued energization of heating coil 79.

Energization of the heater 21 will continue until substantially all of the water in the tank has been heated to a temperature on the order of 150° F., at which time the lower thermal heater control switch 25 will be effective to open the circuit for the heater 21.

If now during a part of the day when the current in the second load circuit is below said predetermined value, hot water is withdrawn from the tank in a relatively small quantity only, sufficient to subject the tube 27 to cold water, the closed switch 25 and the closed switch 47 will cause energization of the heating coil 79 so that the thermal retarder switch will be moved to closed position with an adjustable predetermined time delay period because of the expansion of rod 105. If, however, a relatively large amount of hot water is withdrawn, during this delay period, so that the thermal retarder switch is subject to cold water, the contraction of the first expansion rod 87 will be such as to cause immediate closure of the first circuit including the heater 21.

It is obvious that the heater control system embodying my invention and including a form of thermal retarder either that shown in the drawings or its equivalent will be effective to prevent energization of the tank water heater during such times of a twenty-four hour day when the load on the other circuits of the house is above a predetermined amount, will permit immediate energization of the tank water heater when relatively large amounts of hot water have been withdrawn from the tank and will cause energization of the tank water heater with a predetermined time period of delay in case only relatively small amounts of hot water have been withdrawn from the tank, during such time as the load on the other house circuits is below said predetermined amount.

Various modifications may be made in the system embodying my invention without departing from the spirit and scope thereof and all such modifications clearly coming within the scope of the appended claims shall be considered to be covered thereby.

I claim as my invention:

1. A water heater control system for a hot water tank having an electric heater, comprising a first electric circuit for said heater, a heater control switch in said circuit, a second electric circuit, switching means for said electric heater in said first circuit controlled by the current flowing in said second circuit and moved to open position when more than a predetermined amount of current is flowing in said second circuit and a thermal retarder for actuating said heater control switch, said thermal retarder comprising a first thermally-expansive member subject to tank water temperature at an intermediate portion of the tank a second thermally-expansive member out of close thermal relation with said tank, a heating coil for said second member controlled by said switching means and means mechanically connecting said two thermally-expansive members to said heater control switch to cause closure thereof when said two thermally-responsive members are at substantially ordinary room temperature and attendant energization of said electric heater immediately after reclosing of said switching means upon reduction of the amount of current flowing in said second circuit to a value below said predetermined amount and in case the first thermally-responsive member is subject to cold water.

2. A water heater control system for a hot water tank having an electric heater, comprising a first electric circuit for said heater, a heater control switch in said circuit, a second electric circuit, switching means for said electric heater in said first circuit controlled by the current flowing in said second circuit and moved to open position when more than a predetermined amount of current is flowing in said second circuit and a thermal retarder for actuating said heater control switch, said thermal retarder comprising a first thermally-expansive member subject to tank water temperature at an intermediate portion of the tank a second thermally expansive member out of close thermal relation with said tank, a heating coil for said second member controlled by said switching means and means mechanically connecting said two thermally-expansive members to said heater control switch to cause opening thereof when the expansion characteristics of said two thermally-responsive members are substantially the same and to cause closure of said heater control switch and attendant energization of said heater after a predetermined time period of delay after reclosing of said switching means upon reduction of the amount of current flowing in said second circuit below said predetermined amount, in case the first thermally-responsive member is subject to hot water.

3. A water heater control system for a hot water tank having an electric heater, comprising

a first electric circuit for said heater, a heater control switch in said circuit, a second electric circuit, switching means for said electric heater in said first circuit controlled by the current flowing in said second circuit and moved to open position when more than a predetermined amount of current is flowing in said second circuit and a thermal retarder for actuating said heater control switch, said thermal retarder comprising a first thermally-expansive member subject to tank water temperature at an intermediate portion of the tank a second thermally-expansive member out of close thermal relation with said tank, a heating coil for said second member controlled by said switching means and means mechanically connecting said two thermally-expansive members to said heater control switch to selectively actuate the latter to open and to closed position in accordance with the relative temperatures of the two thermally-responsive members and selectively effective to cause energization of the heater substantially immediately after reclosure of said switching means upon reduction of the amount of current flowing in said second circuit below said predetermined amount in case said first thermally-responsive member is subject to cold water, to delay energization of the heater for a predetermined time period of delay after reclosure of said switching means in case said first thermally-responsive member is subject to hot water and to cause energization of said heater during said delay period in case said first thermally-responsive member was subject to hot water at the time of reclosure of said switching means and then became subject to cold water during said delay period because of the withdrawal of hot water from the tank.

4. A water heater control system for a hot water tank having an electric heater, comprising a first electric circuit for said heater, a first heater control switch in said circuit, a second electric circuit, switching means for said electric heater in said first circuit controlled by the current flowing in said second circuit and moved to open position when more than a predetermined amount of current flows in said second circuit, a thermal heater control switch in said first electric circuit subject to tank water temperature at the lower end portion of the tank, said first heater control switch, said switching means and said thermal heater control switch being connected in series with each other and with the electric heater and a thermal retarder for actuating said first heater control switch, said thermal retarder comprising a first thermally-expansive member subject to tank water temperature at an intermediate portion of the tank, a second thermally-expansive member out of close thermal relation with said tank, a heating coil for said second member controlled jointly by said switching means and said thermal heater control switch and means mechanically connecting said two thermally-expansive members to said first heater control switch to cause closure thereof when said two thermally-expansive members are at substantially the same relatively low temperature with attendant energization of said heater immediately after reclosing of said switching means upon reduction of the amount of current flowing in said second circuit to a value below said predetermined amount and in case said first thermally-responsive member is subject to cold water.

5. A water heater control system for a hot water tank having an electric heater, comprising a first electric circuit for said heater, a first heater control switch in said circuit, a second electric circuit, switching means for said electric heater in said first circuit controlled by the current flowing in said second circuit and moved to open position when more than a predetermined amount of current flows in said second circuit, a thermally-actuable heater control switch in said first electric circuit subject to tank water temperature at the lower end portion of the tank, said first heater control switch, said switching means and said thermally-actuable heater control means being connected in series with each other and with the electric heater and a thermal retarder for actuating said first heater control switch, said thermal retarder comprising a first thermally-expansive member subject to tank water temperature at an intermediate portion of the tank, a second thermally-expansive member out of close thermal relation with said tank, a heating coil for said second member controlled jointly by said switching means and said thermally-actuable heater control switch and means mechanically connecting said two thermally-expansive members to said first heater control switch to cause closure thereof when said two thermally-expansive members are at substantially the same relatively low temperature with attendant energization of said heater immediately after reclosing of said switching means upon reduction of the amount of current flowing in said second circuit to a value below said predetermined amount and in case said first thermally-responsive member is subject to cold water, and to cause closure of said first heater control switch with a predetermined time period of delay after reclosure of said switching means upon reduction of the amount of current flowing in said second circuit to a value below said predetermined amount and in case said first thermally-responsive member is subject to hot water and said thermally-actuable heater control switch is subject to cold water.

6. A water heater control system for a hot water tank having an electric heater, comprising a first electric circuit for said heater, a first heater control switch in said circuit, a second electric circuit, switching means for said electric heater in said first circuit controlled by the current flowing in said second circuit and moved to open position when more than a predetermined amount of current flows in said second circuit, a thermally-actuable heater control switch in said first electric circuit subject to tank water temperature at the lower end portion of the tank, said first heater control switch, said switching means and said thermal heater control means being connected in series with each other and with the electric heater and a thermal retarder for actuating said first heater control switch, said thermal retarder comprising a first thermally-expansive member subject to tank water temperature at an intermediate portion of the tank, a second thermally-expansive member out of close thermal relation with said tank, a heating coil for said second member controlled jointly by said switching means and said thermal heater control switch and means mechanically connecting said two thermally-expansive members to said first heater control switch to cause closure thereof when said two thermally-expansive members are at substantially the same relatively low temperature with attendant energization of said heater immediately after reclosing of said switching means upon reduction of the amount of current flowing in said second

circuit to a value below said predetermined amount and in case said first thermally-responsive member is subject to cold water, and said thermally-actuable heater control switch being effective to cause deenergization of said electric heater when substantially all of the water in the tank is hot.

7 A water heater control system for a hot water tank having an electric heater, comprising a first electric circuit for said heater, a first heater control switch in said circuit, a second electric circuit, switching means for said electric heater in said first circuit controlled by the current flowing in said second circuit and moved to open position when more than a predetermined amount of current flows in said second circuit, a thermally-actuable heater control switch in said first electric circuit subject to tank water temperature at the lower end portion of the tank, said first heater control switch, said switching means and said thermal heater control means being connected in series with each other and with the electric heater and a thermal retarder for actuating said first heater control switch, said thermal retarder comprising a first thermally-expansive member subject to tank water temperature at an intermediate portion of the tank, a second thermally-expansive member out of close thermal relation with said tank, a heating coil for said second member controlled jointly by said switching means and said thermally-actuable heater control switch and means mechanically connecting said two thermally-expansive members to said first heater control switch to cause closure thereof when said two thermally-expansive members are at substantially the same relatively low temperature with attendant energization of said heater immediately after reclosing of said switching means upon reduction of the amount of current flowing in said second circuit to a value below said predetermined amount and in case said first thermally-responsive member is subject to cold water, and to cause closure of said first heater control switch with a predetermined time period of delay after reclosure of said switching means upon reduction of the amount of current flowing in said second circuit to a value below said predetermined amount and in case said first thermally-responsive member is subject to hot water and said thermally-actuable heater control switch is subject to cold water and said thermally-actuable heater control switch being effective to cause deenergization of said electric heater when substantially all of the water in the tank is hot.

8. A water heater control system for a hot water tank having an electric heater, comprising a first electric circuit for said heater, a heater control switch in said circuit, a second electric circuit, switching means for said electric heater in said first circuit controlled by the current flowing in said second circuit and moved to open position when more than a predetermined amount of current is flowing in said second circuit, a thermally-actuable heater control switch connected in series circuit with said heater control switch and switching means and a thermal retarder for actuating said heater control switch, said thermal retarder comprising a first thermally-expansive member subject to tank water temperature at an intermediate portion of the tank, a second thermally-expansive member out of close thermal relation with said tank, a heating coil for said second member controlled by said switching means and means mechanically connecting said two thermally-expansive members to said heater control switch to cause opening thereof when said two thermally-responsive members are at substantially different temperatures and to cause closure of said heater control switch and attendant energization of said heater after a predetermined time period of delay after reclosing of said switching means upon reduction of the amount of current flowing in said second circuit below said predetermined amount in case the first thermally-responsive member is subject to hot water and said thermally-actuable heater control switch being effective to cause deenergization of said electric heater when substantially all of the water in the tank is hot.

9. A control system for an electric heater for a hot water tank comprising a heater circuit, a second house load circuit, three dependent switch units for opening and closing said heater circuit, the first switch unit being controlled by the current in said second circuit and being in closed position when the current in said second circuit is below a predetermined amount, the second switch unit being a thermally-actuable switch subject to tank water temperature at the lower end of the tank and being closed when subject to cold water, the third switch unit including a thermo-sensitive unit subject to heat exchange with tank water intermediate the ends of the tank and another thermo-sensitive element subject to heat exchange means independent of the tank water and operated by power from the circuit when said first and second switches are closed, said switches being effective to selectively energize said heater immediately and with a predetermined time delay period after closure of said first switch in dependence upon the amount of cold water then in the tank.

10. A control system for an electric heater for a hot water tank, comprising a heater circuit, a second house load circuit, three switch units connected in series circuit with each other and the electric heater for opening and closing said heater circuit, the first switch being controlled by the current in said second circuit and being in closed position when the current in said second circuit is below a predetermined value, the second switch unit being a thermally-actuable switch subject to tank water temperature at the lower end of the tank and being closed when subject to cold water, the third switch being a thermal retarder switch including one thermo-sensitive element subject to heat exchange with tank water intermediate the ends of the tank, a second thermo-sensitive element subject to heating applied independently of tank water and heating means operated by power from the circuit for heating the second element when said first and second switches are closed, said switches being jointly effective to cause energization of said electric heater with a predetermined time delay period after closure of said first switch in case the tank contains only enough cold water to reach said second switch and immediately after closure of said first switch in case the tank contains enough cold water to effect said one thermo-sensitive element of the third switch.

11. A control system for an electric heater for a hot water tank comprising a heater circuit, a second house load circuit, three dependent switch units for opening and closing said heater circuit, the first switch unit being controlled by the current in said second circuit and being in closed position when the current in said second circuit is

below a predetermined amount, the second switch unit being a thermally-actuable switch subject to tank water temperature at the lower end of the tank and being closed when subject to cold water, the third switch unit including a thermo-sensitive unit subject to heat exchange with tank water intermediate the ends of the tank and another thermo-sensitive element subject to heat exchange means independent of the tank water and operated by power from the circuit when said first and second switches are closed, said switches being effective to selectively energize said heater immediately and with a predetermined time delay period after closure of said first switch in dependence upon the amount of cold water then in the tank, said second switch being effective to deenergize said electric heater when substantially all of the water in the tank is hot.

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